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THE SCIENTIST ON THE FARM.

LYMAN C. WOOSTER.

IN TIMES PAST the scientist and the farmer have not been especially congenial companions. The scientist has found in the farmer too much to be corrected, and even censured, and the farmer has found in the scientist too much that seems to him to be visionary and uncertain to make these two, who ought to be the best of friends, seek each other's society. Farmers have been known to go miles out of their way to avoid passing a schoolhouse where a scientist had been advertised to lecture. One or two reasons for this incompatibility may well be mentioned here.

Farmers generally have been well trained in times past in the deductive methods of reasoning. The certainties of mathematics and the traditions of their forefathers were emphasized at home and in the public schools. The phases of the moon fixed the date of his sowing, planting and butchering; while drought, insect pests, and rust and smut were evils to be endured or exorcised by the priest.

The scientist, an expert in all forms of inductive reasoning, adds his own observations and experiments to those of a hundred other scientists, and thus reaches conclusions of far higher validity than those reached by a long chain of his ancestors through chance experiences. To be sure, new observations and experiments may lift his conclusions to higher and still higher planes of certainty, but these generalizations must always have far higher validity than the traditions of the fathers.

Of all people engaged in industrial pursuits the farmer is most in need of the power of prophecy, for he is surrounded by variables. The weather, his crops, his animals and his hired help are all in a condition of change, favorable to his interests or sometimes against them, and always requiring the powers of a scientist-seer to foretell the outcome.

THE SCIENTIST-FARMER.

When a scientist becomes farmer he at once takes up the task of elevating his conclusions to higher and still higher planes of validity. To do this he becomes in turn geologist, chemist, physicist, botanist and zoölogist.

As a geologist he studies the soils of his several fields and learns that the clay is derived from an underlying or near-by clay rock or shale (sometimes wrongly called soapstone), or has been brought from a far-away shale bed by some stream at flood from recent rains. Should our geologist-farmer live in northeastern Kansas instead of in Lyon county, he soon learns that a glacier shoved his soil from some near or far deposit to the north. He also learns that the clay of his soils may be the residuum of a bed of limestone. He remembers, furthermore, that he was taught when he studied geology that all the clay of eastern Kansas came originally from the feldspar of decaying granite in the Ozarks of Missouri or in the Arbuckle and Wichita mountains of Oklahoma, and that this is the reason that there is so much alkali in clay soils. (White alkali is chiefly sulphate of potash or soda, and black alkali is composed principally of carbonate of soda or potash.) In a similar way, sand is derived from sandstone, and this from the quartz of granite; but humus comes to the soil only through slow decay of plants and animals.

Then each in turn and all together the farmer-scientist brings to bear on the right solution of the many farm problems all the knowledge gained by the chemist, the physicist, the physiologist, the botanist and the zoölogist, and thus by myriad observations, experiments and conferences establishes conclusions of the highest validity, conclusions of far higher validity than those reached through tradition and casual observation.

Having stated his reasons for believing that the scientist-farmer is far better equipped with general principles of agriculture, gained by the inductive method of science, and why, when thus equipped, he can do with far greater certainty all classes of farm work, the writer desires next to give very briefly, for purposes of illustration, some of his own conclusions respecting farm soils and crops, assuming for the time being that he is a scientist and has been a farmer.

SOILS: QUALITIES AND USES.

1. SOIL BODY.—This is soil framework only.
    - *a. Clay:* Particles one five-thousandth to one two hundred fifty-thousandth of an inch in diameter. Clay is firm, slow and sticky.
    - *b. Silt:* Intermediate between clay and sand.

- *c. Sand:* Particles one twenty-fifth to one five-hundredth of an inch in diameter. Sand is loose, quick and not sticky.
- *d. Gravel:* Particles three inches to one twenty-fifth of an inch.
- *e. Stone:* Three feet down to three inches in diameter.
- *f. Humus:* A corrective of either clay or sand.
- *g. Water and air:* Fill soil pores.
- *h. Remark:* The loams consist of the various soil ingredients in different proportions, and are named accordingly. These are: clay loam, silt loam, sandy loam, gravelly loam, stony loam, and muck loam or humus loam. These terms are useful in soil surveys.

2. Soil Solutes.—Of direct value to crops in food making.
   - *a. Carbonic acid:* Source of carbon in food-making by green plants.
   - *b. Water:* Source of hydrogen and oxygen in food making by green plants.
   - *c. The saltpeters and other nitrates:* The only source of nitrogen for green plants in food-making.
   - *d. Gypsum and other sulfates:* The only source of sulfur for food-making by green plants.
   - *e. Phosphate rock and other phosphates:* The only source of phosphorus for green plants in food-making.
3. Soil Solutes.—Of indirect value to crops in food making.
   - *a. Potash compound:* Necessary to green plants in sugar production. How used is not known.
   - *b. Humus:* Used as food by nitrogen-fixing and other bacteria. Humus is essential to soil fertility.
   - *c. Iron compound:* A necessity in the manufacture of chlorophyll, though not a part of it.
   - *d. Limestone:* Neutralizes harmful organic acids.
   - *e. Water:* A universal solvent and a transporting agent.
   - *f. Silica:* Probably useful in protecting the stems of the grasses (the grains) against the attacks of sucking insects.
   - *g. Common salt:* Possibly useful in very small amounts, but in large amounts retards the endosmosis of water.

SOIL SURVEY MAPS.

Reports on the soils of Cherokee, Greenwood, Riley and Shawnee counties with large soil maps have been prepared by men from the United States Department of Agriculture in conjunction with men from our Agricultural College. Several other areas have been surveyed; but so far as the writer knows, reports on these areas have not been published. These surveys seem to have been carefully made, but the writer would like to make three suggestions which, if followed, would in his opinion make future survey reports more serviceable.

1. The writer would show the origin of the several soils by printing small geological maps of the several counties surveyed.
2. He would drop from the names of the several soils such meaningless terms as Oswego, Selby, Osage, Boone and Crawford. These terms cannot, from the nature of the case, apply to soils of several counties east or west.
3. The writer believes that the small maps of the Illinois soil surveys are more serviceable.

RESPIRATION.

It is now well understood by all physiologists that plants as well as animals need a constant renewal of the supply of oxygen in every living protoplasmic cell to release the energy locked up in the sugars, oils and proteins for the cell activities, or they die. But it is not so generally understood that the stem and root cells get their supply of oxygen from the soil; hence the need of thorough aëration of the soil through deep and frequent cultivation. The sandy loams and the silt loams are naturally more porous and better aërated than the clay loams; hence the need of more humus and more thorough cultivation of the last.

PLANT AND ANIMAL FOODS.

Foods are now defined as those substances which can be so changed by enzymes (usually from colloids to crystalloids, or from oils to soaps or emulsions) that they may be taken through the walls of living protoplasmic cells, and in the cells be used for the increase of protoplasm, or be oxidized for the release of energy. The starch and gluten of kernels of corn, wheat, rice, barley, etc., are as truly foods, under this definition, for the embryos of these seeds as they are for animals when they eat them. Much of the oil of most seeds is already in the embryos while these are in a resting condition, and may have been manufactured in the cell where found, but these oils still possess an essential quality of food—they may be oxidized for energy. The indefensible practice of calling certain mineral substances plant foods is being rapidly abandoned by scientists, and only lingers in textbooks of agriculture and in the advertisements of dealers in fertilizers.

AN UNSCIENTIFIC PRACTICE.

The major premises or the general principles of the mathematical and physical sciences, when established inductively by a genius in science, can thereafter be applied with great certainty by other minds to appropriate particulars in the field of arithmetic, algebra, geometry, physics and chemistry. No higher vision of truth results, but there is much satisfaction in the rediscovery of old truth and in the finding of new applications. In the mathematical sciences, textbooks from one to twenty centuries old are nearly as serviceable as when written. The form of the content only has changed. In physics and chemistry men of genius are still at work elevating some of the general principles.

The biological sciences, fortunately, can never come to rest. The life of plants and animals is a variable. The inherited race habits of species may persist for centuries with little change, but the conscious powers of the individual are constantly seeking new adjustments to their environment and thus modifying the race habits or instincts, otherwise evolution is an idle dream.

The biological sciences are young, and even the fixed tendencies of plants and animals cannot be formulated with certainty. Therefore the biologist must reason inductively to general principles that are mounting higher and higher, and thus having wider and wider application. Few textbooks on plants and animals are worth much when ten years old.

No biologist who keeps up with his sciences can grow old and static. The springs of life must keep ever fresh in his soul. The same cannot be said of the effects of the deductive sciences.

The tendency to follow set forms without change is illustrated by some tables prepared by the chemist for the information of farmers, usually unskilled in interpreting the technical formulæ of that science. It will be noted in the above table on soils that all the solutes, of both direct and indirect value to green plants in the preparation of their foods, are mineral salts except three or four.

As plants have developed the instinct to get their food elements from such compounds, these salts are the soil fertilizers, and all tables giving these fertilizers should give them in the form of salts and not as oxids, the usual practice, or the amount of the food elements present may be given in grams and percents. Many chemists believe that the second method, that of designating the fertilizer by its food element or elements, is to be preferred. The chemical analysis would then give the weight of each chemical element in the fertilizer that will be of use to plants. The current practice is illustrated in the following table given in a much-used book on agriculture. This table gives the tons of "essential plant food" per acre-foot of different types of soil:

Table of "Essential Plant Foods."

	Sandy soil, tons.	Clay soil, tons.	Loess soil, tons.	Humus soil, tons.
Potash (K_2O)	2.42	6.38	8.70	6.39
Lime (CaO)	1.70	12.34	116.40	37.86
Magnesia (MgO)	.96	9.12	73.84	8.68
Phosphoric acid P_2O_5	1.74	2.82	4.00	1.50
Sulphuric acid SO_3	1.10	1.50	1.80	1.48

This and other tables given by the author of this book are of high value when translated into modern scientific language. When so translated the tables will be true in fact and in science; now they are true in form to neither. Potash is caustic potash, and no one who knows its qualities would think of using it as a fertilizer, and still less would he class it as a plant food. In the form of a salt, such as potassium carbonate, it is a valuable accessory plant food. The same may be said of lime and magnesia. Phosphoric acid is H_3PO_4, not P_2O_5, and sulphuric acid is H_2SO_4, not SO_3. Both of these are destructive to plant tissue and are never used as fertilizers unless they are in combination with some base forming a salt. Furthermore, not any of the oxids listed in the above table is found as an ingredient of any soil, and therefore the table is false in fact as well as in chemistry, and in plant economy except to one versed in ancient science. It is true that, according to the modern theory of solutions, mineral salts are believed to be dissociated into cations and anions. Thus potassium sulphate is thought to be dissociated in a water solution into the metal potassium (cation) and the negative radical, sulphur tetroxid (anion). But neither of these ions has the composition given in the above table, and therefore the table is incorrect in all respects when considered in the light of modern science.

SUMMARY.

Most of the general principles (major premises) of mathematics and the physical sciences have been the property of the human race for hundreds, and some of them for thousands, of years. They constitute the salted-down portion of human knowledge, and exhibit no life or power of growth.

The general principles (major premises) of the biological sciences are being constantly elevated to higher levels of truth through the efforts of thousands of observers and experimenters in inducting new truth.

The scientist on the farm bewilders and even disgusts the old-time farmer with his new methods of farming, but the better crops of the scientist and his greater profits in raising sheep, hogs, cattle and horses are slowly convincing the neighbor farmer that the inductive methods of the biological sciences are best. High-bred seed crops and high-pedigreed domestic animals are slowly displacing the scrub plants and animals of his ancestors. Drought loses its terrors when faced by irrigation ditches and drought-enduring seed plants. Traditions brought from a far different environment are being dispelled by the warming influence of scientific common sense.

STATE NORMAL SCHOOL, EMPORIA.

HEREDITY AND EDUCATION.

LYMAN C. WOOSTER.

SOME of the powers of the human mind are evidently inherited, some are developed through contact with the natural environment, and some are certainly strengthened through the agency of schools; but just what part is played by each of these agencies, and just how much the adult mind owes to each, is a question that must be answered before the worth of schools and school studies can be determined.

1. *Is life an entity with powers of its own?*

Man's first inheritance from his parents is a tiny sphere of protoplasm—a fertilized egg cell, one one-hundredth of an inch in diameter. This sphere contains what are commonly known as matter, energy, and life. The matter of protoplasm consists of carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus—six elements not at all uncommon in other forms of matter. The energy, as is well known, is obtained by oxidation of food material stored with the protoplasm in the tiny sphere. Life, the chief entity of this fertilized egg cell, is said by the vitalist to control the matter through the energy,